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Other climate-change inputs.

A vigorous correspondence appeared in Physics Today (October 2008, page 10) regarding the Opinion piece "Is Climate Sensitive to Solar Variability?" by Nicholas Scafetta and Bruce West (Physics Today, March 2008, page 50). One letter writer, Peter Foukal, pointed out that neither total nor UV solar irradiance can account for most of the climate variance that correlates with solar activity. In view of the quantitative problems in using irradiance to account for the correlated climate variations, the question can be asked: Are the cosmic-ray variations, which are mostly due to solar activity, themselves drivers of climate change, or are they – as generally assumed - merely proxies for irradiance variations?

Not mentioned was observational evidence for greater long-term and short-term climate sensitivity to solar activity than irradiance can account for. Proxies for climate change on the centennial and millennial time scales such as glacier carried debris and the oxygen-18 isotope show strong correlations with the cosmic-ray generated cosmogenic isotopes carbon -14 and beryllium-10 in stratified geological repositories[1].

One little known mechanism coupling solar activity to the atmosphere has been shown to respond to cosmic-ray changes as well as to other inputs, as documented and reviewed in recent publications.[2,3] Clear evidence of meteorological responses, including changes in cloud cover, have been reported for five disparate short-term solar or terrestrial inputs that modulate the flow of the downward electric current density J_z of the global electric circuit through the atmosphere. For example, recent analysis of measurements in both the Antarctic and Arctic high magnetic-latitude regions show correlations of surface pressure and the north-south component of the interplanetary electric field. Changes in J_z due to low-latitude thunderstorms produce a similar effect on polar surface pressure.[2] There are other consistent, statistically significant atmospheric responses to the effects of cosmic ray, solar proton and relativistic electron precipitation on J_z.[3]

The J_z flow deposits electric charge on droplets and aerosol particles in gradients of droplet concentration, humidity, and therefore resistivity in clouds, in accordance with Ohm's Law and Gauss's Law. Such charges can affect clouds through the scavenging rates for cloud condensation nuclei and ice forming nuclei. Consequent changes in the concentration of such nuclei can affect droplet concentration, precipitation rate, and cloud cover and can potentially explain the observations. But to model the effects of the cloud changes on global mean temperature on the century timescale it will be necessary to separately evaluate the effects on solar-induced J_z changes on clouds at low and high altitudes; high and low latitudes; over ocean and land, by day and by night; and for stratus versus cumulus clouds. Such work has not been done, but the uncertainties appear much larger than those shown for the solar irradiance effect in the reports of the Intergovenmental Panel on Climate Change, and thus can accommodate the observed changes in global temperature that correlate with solar activity.

References
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3. B. A. Tinsley, The global atmospheric electric circuit and its effects on cloud microphysics, *Rep. Prog. Phys*., **71,** 066801 **(**2008).

(*Tinsley@UTDallas.edu*)
University of Texas at Dallas,
Richardson
http://www.utdallas.edu/physics/faculty/tinsley.html